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TREATISE

ON

THE ŒCOPHORA OF WHEAT

(ŒCOPHORA TEMPERATELLA)

BY

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CYPRUS.

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1908.

HONOURABLE CHIEF SECRETARY,

SIR,

In accordance with the request of the Government I have the honour to submit my treatise on the œcophora of corn.

The study of such subjects cannot be carried out with due accuracy and complete exhaustiveness, although such a deep and minute investigation of matters will render works, such as this, treasuries of useful and practicable advice. The work of an author might be capable, so to speak, of adorning literature of science and yet not of serving in the farmer's hands for combating the plant diseases in his fields.

In order that such treatises may fulfil the desired object, they need to observe the followng conditions the realisation of which will, one can easily see, meet in every step with obstacles hard to pass over.

(*a*) The investigator should give up his whole time to the study of the subject; but this would be opposed to the service of the Director of Agriculture, who has, besides, other work and other occupations. His whole devotion to the former would involve the entire wreck of the latter.

(*b*) Long observation.

(*c*) Full and ample supply of the means required.

(*d*) Sufficient development of the relative local arts and sciences.

One can, of course, have recourse to the works of foreign authors; but as their advice does not result from the study of the local form of botanic diseases, it is by no means a useful assistance. This method not infrequently causes a failure or damage for the reason that the observations of such authors had not in view the climatological and geographical differences of the country, which often bring about in each country special diseases of the indigenous flora; and sometimes give even to the very common diseases some peculiar aspect, which may be of grave importance.

The naturalist, who studies the local microcosm resembles an explorer in unknown countries. Besides patience and perseverance, they both must be supplied with all the necessary means so as to face the obstacles which spring up from everywhere.

In spite of all these difficulties I have been fortunate enough by means of proper experiments, on the spot, to closely follow the phases and changes which this enemy of cereals in this country undergoes during its lifetime. The illustrations given below were made by me from nature. Besides them I have stuck some specimens of attacked leaves of cereals. I am sending at the same time separately some well prepared specimens of this destructive insect in its various forms, and also some microscopical preparations to show the success of what are represented. All those parts of the insect, whose natural size is too small, have been drawn by me to the necessary scale of magnitude.

The explanation of a statement by means of illustrations greatly aids in comprehending the description of a plant disease, and one can say that the representation of such disease through painting and especially in colours is far preferable to that with words, however faithfully and clearly they may be expressed. The mere comparison of the illustrations when successfully made, is sufficient for one to fully understand the thing represented, notwithstanding the looseness and imperfection of the written speech. It often happens, especially with uneducated people, that a description without a pictorial representation leads to errors worse than ignorance. In general, the absence of figures makes reading tiresome, even to scientific men. I therefore indulge the belief that the Government will appreciate the illustrated portion of my work much more than this actual treatise, as the latter without the former would not be regarded as particularly useful and advantageous. I moreover beg to add that, in accordance with your verbal instruction and as the matter concerns an insect known only by name, I have endeavoured to make my report thereon as scientific as possible.

Thus I have been able to draw up this treatise, which is far from being as perfect as is desired, but yet capable of affording no small assistance to those who are desirous of employing themselves in that direction.

I have the honour to be,

Sir,

Your obedient Servant,

DIOMEDE SARACOMENOS.

INTRODUCTION.

PLANTS being governed by unchangeable laws of life are liable to suffering and disease like all creatures of the animal kingdom. Any injury to the physical functions of a plant, which endangers its life or its constitution or natural formation is called a plant disease. Such disease may be due either to causes operating within the plant organism itself or to external agents.

2. Owing to the laws, under which plants live, their existence entirely depends on the favourable or unfavourable state of their surroundings, without being able to resist the injurious or pernicious forces, which in various ways attack them. Animals, enlightened by a degree of more or less intelligence or unconsciously driven by the instinct of self preservation, are able to combat their natural enemies. Does a storm arise, the animal hastens to take shelter under the hospitable projection of a rock or in the depth of some cavern, or seeks refuge in its nest. Do scorching rays heat the atmosphere, the animal shelters in the cool shade of the leafy trees or seeks invigorating currents of air and the refreshing caresses of water. But the unfortunate plant, fixed in the ground, suffers with passive patience both from the caprices of the sky, to which it extends its foliage in order to inhale the lifegiving air, and from the poverty or unkindness of the soil, to the mercy of which it reaches its branchy roots to beg food. The plant then lives, blooms and develops by getting all its powers and properties when it obtains from the earth and air the strength needed for its existence. Failing this, and whenever the conditions of life, being altered or changed, interfere with its regular functions, it will suffer and die. The soil and air then are the chief sources of disease in the body of the plants.

3. Plants are also subject to external diseases. These are due to the organisms, which settle on them and live and feed on their sap or flesh.

4. So much in general about the nature of plant diseases. Now let us examine the plant with reference to the world around it, with which it is in continual contact and relation. In order to maintain the harmony and balance-sheet of credit and debit of the vital functions of the plant turns the struggle for existence of each plant in general, and the comprehension of that case would afford a true idea about the distinction between the real disease of organic beings and the sufferings or attacks to which they are liable from the surrounding animal kingdom, and which we call also diseases or sufferings, because the pathological derangement of the counter-balance of this balance-sheet of the plant with the environment is its veritable disease.

5. On the part of the living environment, that is, from the whole of the approaching animals and of the neighbouring or in some way or other affecting flora, the plant undergoes an injurious influence, sometimes indirect, arising from the strife in disputing for food with other plants growing on the same spot, and bringing cramp or impediment in the development of one of the enemies, and sometimes direct, and such is the case

when the attack is made body upon body, when the plant comes, as it were, into collision with the living organisms around it, and is therefore hurt more directly. Some of the latter feed on its leaves or those parts, where its food aliments are stored; others settle therein as parasites and suck up its sap; others pierce through its bark in order to lay therein their eggs, thus causing protuberances and inflammations, and the offspring profit by the increased sap collected in them. Others again make short work of it by devouring the plant or large parts of it, including also man, who calls himself the king of animals. Some of the above and cryptogamic plants also settle as parasites on the plant.

6. It will be seen from the above that diseases could rather be called chiefly the results of external causes such as heat, cold and excessive rain. Other causes mentioned above will bring about an alteration or even death to a plant or interfere with its regular development. But they can be brought under the chapter of the struggle for existence with other plants or animals.

7. Cereals, like other cultivated plants suffer from countless evils which are due to the above mentioned causes. Numerous organisms belonging either to the animal or vegetable kingdom attack them and destroy their grain, stalks and leaves. Owing to their structure and the rapidity of their growth, they are liable to be affected by atmospheric changes and phenomena. Continuous rains, long dry weather and violent winds have an injurious influence on them, sometimes by interfering with their physiological operations, sometimes by decimating or entirely destroying the crop.

8. In this report I propose to deal with the damages occasioned to cereals by a certain insect, which develops in their leaves. I shall also set forth what, after personal observations and experiments, I consider the best means of combating that insect. It has for a long time ravaged many cornfields in the Island in which it is known as *Sirividhi* or *Sirivis*. Its existence in Cyprus began to be known to the scientific world only in 1889 through the publication in the Bulletin of the Royal Gardens, Kew, page 133, of a brief description of the insect in the form of worm and male moth from specimens sent from Cyprus. The eminent Stainton, to whom the insect was submitted for examination, classified it as a species of Œcophora temperatella, Lederer.*

9. It was only by name that I knew the œcophora of wheat when I first arrived in Cyprus, as I had read about its existence in the Island and the damage caused by it to corn crops in the noteworthy work upon the agricultural conditions in Cyprus by my predecessor Mr. Gennadius. On page 38, Vol. III. of that treatise reference is made to the above named article in the Bulletin. Nothing definite was recorded either in the writings in question or in the departmental papers dealing with this subject, concerning the habits and life history of this animalcule. So I determined to proceed, as soon as my departmental work would permit, to the central home of the pest, that is, to the neighbourhood of Pissouri and Evdimou, and gather what information I could from landowners there. I went there with the District Commissioner, Mr. Michell, who very kindly offered to assist me himself in my work.

* This insect occurs also in Syria and Asia Minor (see the Tineina of Syria and Asia Minor by H. T. Stainton, F.L.S., London, 1847, page 47). In this treatise are given the names of Tineina that are met with in the above mentioned countries, and a short description of the chief features of some of them.

10. Notwithstanding the long interview I had in Evdimou with the leading and most intelligent landowners, I was unable to satisfy myself as to many points in the biological circle of this insect, nor could I even gather the necessary information about the way in which it appeared and propagated. Having regard, therefore, to the amount of damage habitually caused by this insect, and to the fact that its life history, without a full knowledge of which it would be impossible to combat it effectually, was so little known, I decided to investigate the subject in the following winter when the œcophora begins to appear, and to carry out the necessary experiments so as to find out the method of combating the foe. I accordingly selected near Pissouri a piece of land, which I intended to have tilled and sown at the beginning of the winter of 1905, in order that I might closely follow the evolution of the various stages of the insect, as well as the effect of the different methods I employed for destroying it. I had unfortunately to postpone the experiments for a year, as, owing to delay in settling the lease of the land, the sowing of the season slipped by. Immediately after that, however, another piece of land was hired also within the area of Pissouri, which I have tilled with a European plough and sown this year. In order not to lose a whole year, I applied myself to the study of the Sirividhi from last year, and have frequently visited the lands feeding this insect. Thus by often visiting the cornfields attacked by the œcophora, as well as by my observations made this year in the field of Pissouri, I have been able to follow the development of this insect in the various stages and thus complete its biological circle.

11. With the report I give some illustrations of the insect as well as many sketches of its various parts and at different stages of its life. I also give a detailed description of the external formation of the insect in its different stages of development, thus settling also the questions, raised in the above mentioned Kew Bulletin. These questions concern the life history of the insect, and, as I have already said, upon them depends the discovery of a proper means for combating this enemy.

12. The following are the questions which have been propounded in the Kew Bulletin mentioned above :

I. Where the pupa is normally found, whether in the plant or on or in the ground, etc., and the period which elapses before the moth appears.

II. Where the eggs are laid, and whether singly or in camps.

III. In what stage the Sirividhi passes the winter. *

* The Sirividhi does not "pass the winter," but is in a state of activity from the month of December or January to April. It enters a state of lethargy in May and so remains until cereal vegetation is in early growth.

ŒCOPHORA TEMPERATELLA.

LOCAL NAME "SIRIVIDHI OR SIRIVIS." *

THE ŒCOPHORA OF WHEAT is a microlepidopteron belonging to the family of tineina, which in Europe numbers about 170 species. This family together with that of Tortricidœ and Pyralidœ forms the section of microlepidoptera, which includes many insects injurious to profitable plants and to stored crops. Clothes moths belong to the section of microlepidoptera.

The œcophora of wheat is known in Cyprus as the "Sirividhi" (Papho and Limassol) or "Sirivis" (Mesaoria) and has long existed and causes in the grub stage great damage to cereals.

Before I proceed to the description of the life history of the insect now under consideration, I deem it necessary to prelude, for the sake of most of the readers, the following statement concerning the *metamorphoses* of insects, which form the most curious part of the history of these creatures.

When brought forth from the eggs, they are, mostly, very unlike the insects which gave them birth. As though the immense variety of these beings was insufficient, each of them changes, during its lifetime, very unlike forms. These animalcules have, at the end of their existence, forms which differ from those they had in their infancy. Nobody is unaware of the changes the silk-worm undergoes from the time it comes out of the egg until it becomes a perfect insect (imago). This insect is born from the egg as a worm or caterpillar and lives in that form for some days; then its skin hardens, and the worm goes to sleep after having woven its cocoon in which it shuts itself up; when in such a state, it is called a *chrysalis*, from which, after a while, emerges the butterfly, the perfect insect, which now grows no more, but keeps the same size until death.

The perfect insect of the œophora—the butterfly—appears in April and lives from 8 to 12 days. From the first days when the insect seems to take no food, the pairing commences followed by the laying of eggs, which are hatched 10 to 12 days later. The grubs at once seek for shelters, in which they live in lethargy until the beginning of December or January. About the middle of winter, therefore, when cereals commence their development, the worms appear, and climb the plant and penetrate the leaves by opening a gallery between the two epidermises. In this state they live about three and a half months, during which period they feed on the parenchymatous tissue. Then having completed their development, they quit the hospitable plant and descend to the ground where they change into chrysalides. In about fifteen days they come out in the state of perfect insect (imago) which, as we have stated above, live from 8 to 12 days.

This insect has but one generation in a year.

Such is the life circle of the œcophora of wheat. Let us now acquaint ourselves with each of these phases, beginning with the egg.

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* Sirividhia are called in Cyprus specially the grubs of Lepidoptera, which attack the apple-tree, cereals, the vine, etc. According to Mr. Gennadius, my predecessor, this word must be derived from the root *σήρ*, from which *σηροτροφία* (sericulture). The silkworm was called *σήρ* in ancient times.

The egg.—It is very small, 0m,0005 to 0m,0006 in length and 0m,0002 to 0m,0003 in thickness, of yolklike colour, which is due to the *vitellus* therein. The shell or *chorion* of the egg after the worm is hatched out is milky-gray, transparent and bears on its surface a network standing out in relief, each mesh of which presents an equilateral triangle. At first sight the relieves seem to represent hexagons which are cut across into equilateral triangles of equal number by lines running from the centre to their angles. The area of each triangle, if magnified to a larger scale, exhibits an irregular latticework composed of serpentine lines running along its sides.

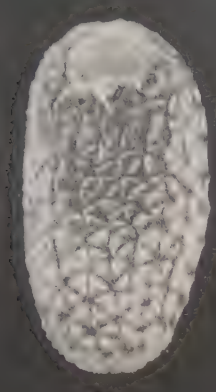

Fig. 1. Egg: (*a*) natural size (*b*) two eggs stuck together (*γ*) magnified, showing the exit by which the grub emerges. (Orig.)

The Worm.—On coming out of the egg, it is hardly ¾ of m.m. long and ¼ of m.m. thick. When about to hatch out, it is of a yellow colour. But in the course of its life, this colour gradually turns slightly orange, then gray, and at the end of the grub period is dark-gray. Then it is 7 or 8 m.m. long and 1½ m.m. thick. Its body is composed of 13 rings, including the head.

The head is small, triangular and is covered with a chitinous tissue sufficiently resisting, of blackish shining colour. Its upper surface is curved and bears in the middle a cavity in the shape of a lyre, the top of which is turned to the front, and closed by the *epistoma*. The head terminates in the upper lip, a thin plate of chestnut colour, with an incision which divides it into two roundish side wings. On both sides there are three-jointed contractile antennæ, behind which are arranged three tiny eyes in semicircle. The jaws of the first pair are chitinous trapezoidal and somewhat curved and of chestnut colour. They are situated horizontally, and, when at rest, cross each other, the right jaw under the left one. Their front side forms a small cavity in the middle; the hind one is curved. Of the two sides

Fig. 2. Head: (*a*) upper view magnified, (*b*) under view magnified. (Original.)

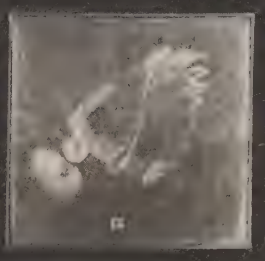

Fig. 3. Jaws: (*a*) upper jaw, (*b*) lower jaw, magnified. (Original.)

the outer side bears at one extremity a round head, by which it is jointed in a corresponding cavity to the skeleton of the head, and a protuberance in the middle and inside extremity where are located the muscles that move the jaws. The inner side is dentated, composed of five sharp teeth arranged in a single row. These jaws are very tiny, the greatest width being equal to 0m,0010. The second pair of jaws is situated on both sides of the lower lip, with which it is jointed. The lower jaws are cylindric, three-jointed organs crowned with articulated palpi. The lower lip bears at its base a shallow cavity and above it two hairy prominences and the upper third part, a spinneret with two tiny appendices. The system of the two latter mouth organs consists of soft pale tissue and, when masticating, it moves rhythmically from inside outward and from below upwards, thus describing a complete circle with its free end, whilst the upper jaws work laterally making in their motion a bow from inside outward.

Of the three sections forming the thorax, the first bears on its upper surface—on either side of the middle line—two triangular patches of chitin of the same stuff and colour as that of the head skeleton. These patches mix with each other at their front part, and are limited from above and below by a curved line, the cavity of which is turned to the front. The second and third sections of the thorax are adorned with folds of the skin, crossing each other in the middle of the back in the form of X. The first fold of the prothorax has two blackish spots, which are larger than those adorning the other segments.

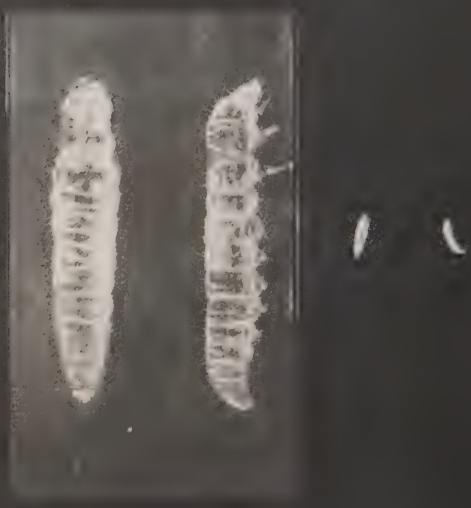

Fig. 4. Worm, natural size and magnified. (Original.)

Each section of the abdomen of the worm bears on the upper surface a slight traverse groove, which divides it into the fore and hind halves. On both sides of the middle line on the two halves of all the abdominal segments there are two brown spots, one after the other, in a row. Similar pairs of spots are also on the lateral parts of the front half of each section. The spots are tiny, mostly having prominences. Along the sides of the worm runs a whitish narrow ribbon on which brown spots are distinguishable on the anterior half of each ring. These are likely to be the *stigmata* or the breathing holes of the insect.

Such brown spots are to be seen on the breast and abdomen on both sides of their middle line. The last abdomen section bears on the upper surface of the hinder half a shining black patch.

Under the three segments of the thorax there are three pairs of legs attached to them. These are the true legs (see Fig 5, b). They are of pale colour and consist of four chitinous segments of which the one of the base is incomplete externally, and the last is armed with a sharp claw. The two segments next to them are single, and the four that come next

bear each a pair of membranebus legs, the prolegs, consisting of contracting nipples on the top of which if magnified strongly, we can see about 20 chitinous hooks, which are blackish, arranged in a single circular row and turned outward (see Fig. 5, a). A similar pair of prolegs is also borne by the last segment of the body. On the upper surface the different rings of the body are covered with thin hairs growing from tiny prominences as we have said.

Fig. 5. (*a*) pro-leg (*b*) leg magnified. (Original.)

A full-grown worm is 7 to 8 m.m. long and 1½ m.m. thick.

Chrysalis.—A chrysalis is 5 to 6 m.m. long and 1½ thick and of yellow colour (see Fig. 6).

PERFECT INSECT, BUTTERFLY.—DESCRIPTION OF THE MALE.

The body of the insect is 5 to 6 m.m. long and its three sections are distinguishable, viz. : the head, the thorax and the abdomen. The colour of its body has the flash of old gold, arising from a very fine scale powder attached very slightly to its body, so that it adheres to the fingers of the person who catches hold of it.

The head is small and bears on each side large eyes of black colour somewhat projecting. The feelers (antennae) are thread-like and long, growing just above the eyes. Their length is equal to that of the body* and about 1 m.m. shorter than the front wings. They are composed of 46 small cylindro-conical joints, the first of which is larger and is covered, as well as the five joints next to it, with scales of golden colour; the rest being enveloped with blackish scales and hairs. Between the eyes and their uppermost part is the proboscis fixed, consisting of the lower jaws, which have changed into a very tiny tube. The proboscis is long (half the length of the body) and can be coiled under the head; it bears on each side and at its base three-jointed appendices, which project from the head, turn abruptly upwards and backwards and give the creature the feature shown in the figure 8. These appendices and the proboscis are adorned by golden scales. Similar scales invest the eyes and the lower part of the head, running round it in the form of a down turned collar. The forehead and the top of the head are also covered with scales but of blackish colour.

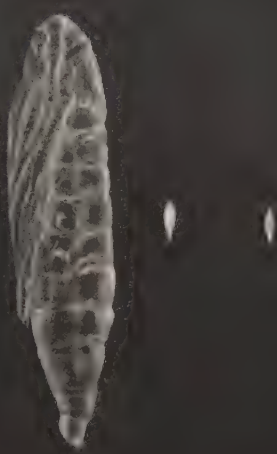

Fig. 6. Chrysalis, natural size and magnified. (Original.)

* The length of the insect from the head to the end of the wings is equal to 7½ m.m.

The rings forming the thorax are distinguishable after the removal of the down, with which they are covered, and can easily be separated from each other. The mesothorax is more developed than the rest and bears a rhomboidal *aspidium* of which the two transversal sides are less curved outward, while the angle above is rounded. The back surface of the part behind the aspidium and the metathorax are covered with blackish scales.

The abdomen is composed of 7 rings covered above and beneath with shining black-brown scales and dotted here and there with golden hairs. The last ring bears the anus and is adorned with fringed hairs, which, are more developed and conceal three pointed appendices, which are the armament of genitals (Fig. 9, a.) Two of these lie on each side of the end of the intestinal tube. They are simple, flattened at the base and move laterally. The third, which is two-jointed, is situated above them, and its last joint moves from above downwards.

Fig. 7. Male moth wings extended (*a*) natural size (*b*) magnified. (Original.)

The wings of both pairs are oblong terminating in an acute angle and project by 2½ m.m. They are membranous, and the fore wings are larger and of golden colour, whilst the hind ones are smaller and dark. Both pairs of wings bear fringed tufts, which adorn the free extremity and one-half of the inner side of the upper wings, while they are more abundant on the lower wings, covering half the fore part and the whole of the hind one. The hind wings bear near the base of their upper side—as is the case with many insects of the section to which these belong—a delicate protuberance, which is a remnant of the costal vein and is turned outward.

The veins of the wings, which become distinct by removing the scales with which they are covered, differ from each other on the fore and hind wings. On the fore wings the *costa* is simple, and the *under costa* (radius) jointed with the *middle one* at the base of the wing, sends forth towards the circumference six branches of which three terminate at the front face of the wing and three *middle ones* lead to its external angle. The *middle* vein is divided into three branches terminating on the inside face of the wing. The two *main middle* veins mentioned above meet at the posterior third of the wing and enclose on the middle of the wing a space, a *cellular disc*. Towards the hinder part of the wing is the vein *cupidus* which is united with the lower or hinder vein, that seems to grow out with two branches from the base of the wing.

Fig. 8. Head of œcophora. magnified. (Original.)

The veins of the hind wing are simpler. The *costa* and *radius* veins grow out of the same root and run direct to the circumference of the wing. The *middle* and *cupidus* veins meet also at the base, the latter forming three branches and the former two. The middle and cupidus do not meet in their

course outward as is the case with the fore wing. There seldom occurs on the wing of the male any trace of the union of these branches (radius sector), and this we point out in the illustration (Fig. 10) with dotted line. The hind vein is simple and joins, at the base, the root of the two veins just preceding it.

The veins above referred to, their number and the manner of their ramification differ in the various families and are of great importance in

Fig. 10. Wings and scales, magnified. (Original.)

the classification of insects. They are tubes between the two skins layers of the wing and covered with chitine and protect the blood vessels, the nerves and especially the tracheae, that ramify in the wings.

With the illustrations of the wings are also given drawings of the various scales, that cover the wings. These scales differ from each other according to the part of the wing they cover. At the upper part of the wings we meet the smaller scales, about the middle of the wing, the middle-sized and at the extremities of the sides, the largest. The hairs forming the fringes, which adorn the extremities of the sides, are shewn in Fig. 10. Similar scales, but of dark colour, also cover the lower wings. The legs bear the characteristics of the family and are covered with golden and dark scales, but simpler in form. The thighs and calves of legs bear on their outward part long and copious golden brown hairs.

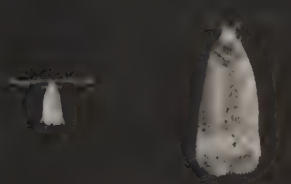

Fig. 11. Female moth, magnified. (Original.)

The female insect is distinguished from the male by the size and form of its body. It is smaller by 1½ m.m. than the male and resembles an isosceles triangle, and bears at the lowest part of the wing a large transversal macula in the form of a broken line. The colouring of its body is less vivid and its abdomen is fusiform. Its last segment is yellowish and is covered with scales of similar colour which form a small tuft at the end. It bears an ovipositor (Fig. 9, b), which is cylindrical,

yellow-brown and equal in size to the abdomen. The ovipositor, when at rest, is hidden altogether in this last segment, into which it is withdrawn like a telescope. It is soft and can move in all directions.

By-the-bye one can notice also smaller in size individuals of both sexes, perhaps a variety of the œcophora. The length of these varies from 4½-5 m.m.

Damage occasioned by them.—The time when the sirividhi worm appears depends on the position of the cornfields and on the temperature of the atmosphere. In the lands near the seaside (Machærona, Macrou at Karpas, Psematismeno, Tochni and Limassol) the œcophora worm makes its appearance in December, and in the fields situated higher (Pissouri, Phassoulla, Limassol) from the middle of January. The early caterpillars will appear sooner if finer weather prevails in December.

The caterpillar, in its early stage, climbs up the stem of the plant and reaches its leaves, and there, after choosing a spot on the upper surface between the veins, it penetrates into the leaf and begins feeding on the parenchymatic tissue, gradually opening a tunnel between the two epidermises, which during its destructive work it takes care to leave untouched. When entering the leaf, the worm is, as we have said, very tiny, hardly ¾ m.m. long and as thick as a hair. Its ascent up the stems of cereals and its original settlement in the leaves, is therefore invisible even to a trained eye. The evil consequently becomes known to most people only long afterwards owing to the slow development of the worm.

Fig. 9. Sexual organs (*a*) male (*b*) female magnified. (Original.)

About the middle of January the visitor to cornfields in localities where this pest prevails, on carefully examining the leaves of corn, will see at the middle and top of them one or two or several tile-coloured spots, more distinguishable on the upper surface, like the rusty spots caused by Puccinia Graminis. On examining the leaf in the light, one may see at this spot a threadlike worm of dull-red colour and behind it a gray-white and transparent line due to the absence of the green tissue of the leaf, which has been consumed by the worm. This whitish line is dotted here and there by some granules of dirty green, the excrements of the caterpillar. This spot of tile-like colour of the worm changes in course of time and becomes darker and at last brown, while its age advances. It turns dark-gray at the last stage of the development of the worm. The opening, through which the worm penetrates into the leaf, in its first stage, is very tiny and invisible to the naked eye. It is to that fact that the different conjectures of the peasants—which are otherwise natural—are due as to the phenomenon of the presence of the worm inside the leaves of cereals without manifest marks of its entrance into them.

The opening of the tunnel between the epidermises of the leaves during the first month is made very slowly. Throughout the early days of its existence the worm is 1½-2 m.m. long, and in one day covers a distance scarcely equal to its length. Therefore, and as the damage is confined between two veins, each leaf can harbour one or two worms sometimes more than a month, without undergoing any substantial change other than

the destruction of the parenchymatic tissue between two parallel veins. The change of the leaf and therefore the withering of it is accelerated when the worm does not keep its course between two fibrovascular sheaves; but when instead, it deviates from the straight course, and, in its passage, destroys many ribs, thus checking the nourishment of the upper parts of the leaves. This quick alteration is seen specially in leaves, which carry many worms (see Fig. 15).

After the lapse of the period above referred to, the withering of the leaf begins, and the worm then has to change residence, and migrate to a healthy leaf, where it will find fresher food. This migration the worm repeats three to four times until the completion of its development. It also changes its abode even when troubled by any cause. The sirividhi, like many other caterpillars, allied to it, resents the approach of strange visitors, while making its peaceful banquet. When one takes hold of the leaf, where the worm lives, it will soon quit it; though, sometimes, it is not sensible of such disturbances.

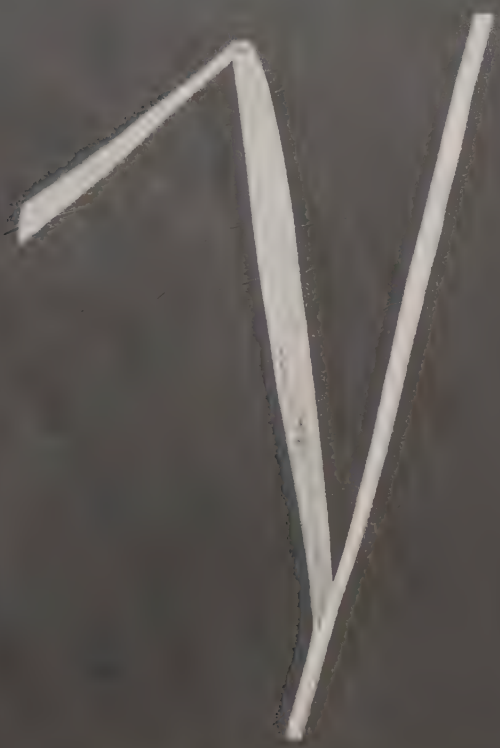

Fig. 12. Wheat leaf, bearing two sirividhi worms, natural size.

When the undermining work of the worms has brought about the destruction of many ribs of the leaf, the latter droops, suspended to the stem merely by the tissue of the epidermis and the remains of fibrovascular sheaves. The part injured then commences to curl and the leaf soon withers and dries up. When the evil is limited, the destruction thus caused to the lower leaves does not bring about substantial injury to the plants, especially when growing in rich moist soil. But when atmospheric conditions favour the excessive multiplication of the dreaded insect and dry weather follows, the change of the leaves quickly ensues and the plants are checked in their development, and sometimes destroyed altogether, the sirividhi worm also perishing for want of food.

When this damage comes in January and favourable weather intervenes, the cereals send forth new and more shoots, which develop freely and yield a more abundant harvest. But usually the evil remains irretrievable, and, in serious attacks from sirividhi the cornfields will then at the active season of vegetation exhibit dwarf and leafless stems crowned with ears in a state of atrophy, which the reaper's scythe scorns to reap.

The œcophora of corn lives in the form of worm for almost 70 days, that is, from the early part of January until the middle of March. Worms, however, also occur up to the end of April; they are the tardy ones which awake later. During that period they pass through the stages of moulting. When about to moult, it retires into its tunnel, and there remains in a somnolent condition for many hours.

Having completed its growth, it quits its hiding place, on emerging of which it remains coiled up. It then begins to move on the leaf and after wandering over it for a while, it descends to the ground either along the stalk of the plant or by means of its delicate web, one end of which it attaches to the leaf. This web issues from a small gland on the upper-third part of the lower lip of its mouth (Fig. 2, b). On reaching the ground, it will soon begin to crawl quickly, and after wandering for some time, during which it often retraces its track, stops at some spot and with its front legs and head opens a hole in the ground, into which it descends in order to change into a chrysalis. Sometimes it assumes the chrysalis from beneath lumps of earth or in crevices of the ground and more rarely even in the leaves themselves. The figure 16 presents such a kind of chrysalis.

The hole through which the worm penetrates into the earth closes behind it, whilst it continues its descent, boring during its progress a narrow passage, which it lines with an araneous web. On reaching a depth of $0^m,003$—$0^m,01$ from the surface of the ground, it enlarges its hiding place to a depth of $0^m,008$ and therein after having lined the walls of it with the araneous web it commences to weave its cocoon, in which it encloses itself up for its metamorphosis. The cocoon is $0^m,007$ long, its walls being thin but sufficiently resisting. The worm here becomes a chrysalis with its head toward the outlet. At the bottom of the cocoon fall the chitinous skeleton of the head, which is open at the bottom, and the remains of its last skin. The worm in the form of chrysalis lives from 15–17 days.

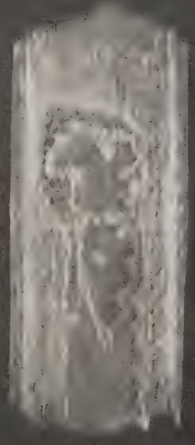

Fig. 13. Entrance hole, caused by the worm, magnified. (Original.)

The perfect insects appear about the middle of April and live from 8–12 days. The butterflies, however, seem to live much longer, as one may meet with butterflies of sirividhi in cornfields attacked by it as late as the 10th of May and even beyond that date. This apparent duration of the life of sirividhi is really due to the gradual metamorphosis of subsequent worms which, of course, become chrysalides later on, and this process lasts up to the latter part of April.

The insect casts the skin of the chrysalis by opening it in front to a depth of $\frac{2}{3}$rds the length of the abdomen. It then creeps up the narrow passage, which it had prepared when in the form of worm and after removing the thick web, which blocks up the hole on the surface of the ground, it emerges from the earth.

The tiny openings, through which the insects come out of the ground are $\frac{2}{3}$ m.m. in size, and cover the whole surface of a field, which, from these borings alone, betrays the fact that it has harboured sirividhi (Fig. 17). The insects thus transformed remain in the same field. Their flight is

Fig. 14. Young barley plants from a field at Pissouri in each leaf of which I counted more than thirty worms.

short, and they limit themselves to moving about among the surrounding plants, even when disturbed. They like to be stationary especially by day, when they rest on the stalks or leaves of cereals with their heads upwards and their antennæ resting on their backs. It is to be noticed that the males always prefer to stand towards the upper part of the plant, whereas the females stay at the base of the stalk. The male butterflies moreover fly away at the first approach of an enemy, whereas the females seem to be less agile, quieter and more easily caught.

Fig. 15. Wheat leaves in different stages of damage, natural size. (Original.)

On the following day after their metamorphosis they seek each other for mating. The males driven by the instinct of perpetuating their species, seem, after the lapse of the above mentioned period, restless even when they are in an abnormal condition—such as when they are confined for experimental purposes. They turn themselves round brandishing their wings, which they keep slightly spread out, go up and down the stalks, and then on meeting the females, stop, move their antennæ, which they turn forward, and then the coupling takes place, the insects joining together at the extremities of the last segments of their abdomen, and turning their back to each other. In this position the ends of the wings of a male partly cover the body of a female. The coupling lasts 2 to 3 hours, during which the insects thus coupled mostly remain still even when troubled by outside causes. After the performance of their coupling the male insect will die within 6 or 7 days and the female endeavours to find a suitable place in which to lay her eggs; she usually chooses the dead leaves of cereals on the ground and even the ground itself. She lays her eggs, which are about 50 one after another and connected with each other like a string of beads (see Figs. 1 (b) and 18). She lays them usually in small patches or groups composed of 5 to 7 eggs. The females, having laid their eggs and fulfilled their destination, die in a few days, and fill the field with their dead bodies.

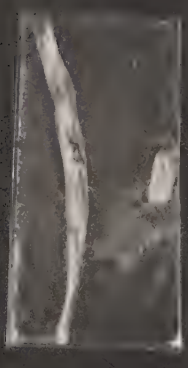

Fig. 16. Chrysalis on leaf, natural size. (Original.)

To find the dead bodies of the insects, one should be prompt, as the ants, which abound in cornfields, quickly remove them, to their nests. Sirividhi eggs are easily discovered owing to their yellow colour. The hatching of the eggs takes place 10 to 12 days after they are laid at the

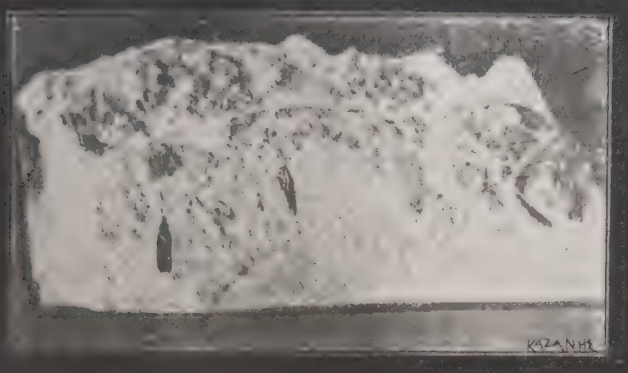

Fig. 17. Cocoons in the soil, natural size. (Original.)

beginning or about the middle of May and the grubs, on coming out of the eggs, seek for shelters under the dead leaves or lumps of earth where they coil themselves up in a thin web and remain in a state of lethargy until the early part of December or January.

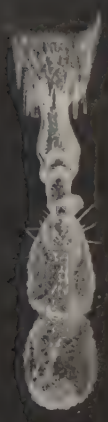

Fig. 18. Last segment of abdomen with depositor in act of deposing eggs, magnified. (Original.)

Places in the Island where the Sirividhi occurs.

The sirividhi is met with in most cornfields in the Island, and the damage it causes depends upon whether the conditions are favourable or otherwise for its development.

The following villages are known to have suffered from this insect.

Papho District :—Meladia, Sarama, Lassa, Simou, Skarphou, Anadiou, Ano Arodes, Kato Arodes, Episcopi, Stroumbi, Polemi, Ano and Kato Archimandritas, Mamonia.

Limassol District :—Episcopi, Asomatos, Yipsonas, Palodia, Apshou, Yerassa, Acrounda, Phinicaria, Phassoula, Armenochori, Alectora, Pissouri, Paramali, Anoyira, Limnati, Corphi, Mathycoloni.

Nicosia District :—Palaekthro.

Famagusta District :—Lefkoniko.

Larnaca District :—Marin, Psematismeno, Tohni.

The œcophora is likely to be met with also in other parts of the Island, but in most villages, the inhabitants of which complain of the damage occasioned by the sirividhi to their crops, this is due rather, as we have been able to ascertain to the grubs of other insects, parasites of cereals, such as Cecidomyia tritici and Sitotroga cerealella, etc. which are collectively called by the people here *Sirividhi*. At any rate, even if we admit that the insect in question is limited only in the above mentioned places, the damage caused by it to

cereals is sufficiently serious to attract the grave attention of all those who can succour the suffering peasants. If we calculate the loss caused annually to cornfields at 30 per cent. only, this alone could amount to the sum of £5000 to £8000 annually.

But often the damage done by the sirividhi is much greater. Thus Captain A. Young, the late Chief Secretary, says in his letter (1889) to Mr. Arthur E. Shipley, Fellow and Lecturer of Christ College, etc., that only in the District of Famagusta, "there were about 27,060 scalas (donums) attacked by the sirividhi and the amount of grain destroyed in this area was estimated at 55,760 bushels of wheat and 13,940 bushels of barley," that is, about £7000. It is therefore easy to understand the interest which every landowner should show in all that concerns the life and habits of that little but terrible enemy of theirs.

We give below a table kindly furnished me by Mr. Michell, the Commissioner of Limassol, showing the damage caused by sirividhi to some villages in the District of Limassol during the period 1903 to 1906.

TABLE A.

Village	Year	Wheat Donums	Barley Donums	Oats Donums	Remarks
Pissouri	1903-4	400	240	120	
Anoyira	1903-4	240	120	100	
Alektora	1903-4	160	140	80	
Evdhimou	1903-4	—	—	—	
Paramali	1903-4	—	—	—	
Total ...	1903-4	800	500	300	
Pissouri	1904-5	1000	275	50	
Evdhimou	1904-5	150	75	—	
Paramali	1904-5	15	—	—	
Total ...	1904-5	1165	350	50	
Pissouri	1905-6	1000	400	100	
Evdhimou	1905-6	100	—	—	
Anoyira	1905-6	50	60	—	
Alektora	1905-6	50	—	—	
Total ...	1905-6	1200	460	100	

In estimating the actual damage as 25 per cent. of the crop attacked, the Commissioner calculates the probable loss in money would be for

1903-4	...	...	£671
1904-5	...	...	£725
1905-6	...	...	£772
Total	...	...	£2,168

An exact estimate cannot be made from this table of the annual average loss in the above localities, as it omits returns from certain villages therein named, and moreover the figures may be regarded as below the actual facts. In the case of Pissouri, for example, the returns here given represent an average loss of about £500 per annum, whereas from my personal observations and from enquiries made by me on the spot, the loss might more correctly be stated as averaging £700 to £800 per annum.

How the pest spreads.—We know nothing about the centre either of the original appearance of the sirividhi nor of its multiplication, nor the route along which it has spread. Its native country may probably have been Asia Minor, where it occurs in many places. In that case its importation into Cyprus would have been by the ordinary channels of communication and trade just as Phylloxera and other insects have invaded Europe from America. It may even have existed always in the Island, living on wild dog-grasses and other plants, on which it continues to live at the present day, and it has thence spread to cereals on which it, by preference, lives, as their leaves furnish more savoury and richer food.

The propagation of the sirividhi is brought about in several ways, and even man may become unconsciously the means of spreading it.

The spreading of sirividhi by means of worms is rare and then only into adjacent fields. When a worm, this insect will develop and become a chrysalis in the same field, in which it finds plenty of food; and this because, as we have said elsewhere the development of the grub in its early stages is very slowly effected, and the plant on which it feeds is thus given time to put forth more leaves, into which the worms make their way after the first leaves have wasted away. This being so, the worms, previous to their metamorphosis, can visit but very few plants.

When, however, the insects appear in large numbers, and when, owing to climatic circumstances unfavourable to the growth of corn crops, the field yields insufficient food for their development, the worms quit the field and seek food elsewhere. But their migration is limited to neighbouring fields. Such migrations are undertaken by those worms on the boundaries of the infested field, and which, having completed their development and descended from the plants in order to become chrysalides, are perhaps seeking a suitable soil for their metamorphosis. I have witnessed such a phenomenon near the village of Alectora.

The second method by which the sirividhi pest is spread is that due to the perfect insects, though the distances covered by them are very short. Otherwise the insects like to stay resting till their death in the same corn-field in which they had first seen the light. Sometimes some of them will emigrate to neighbouring fields. In exceptional cases they may be blown long distances by strong winds. But in considering the spread of the evil, we must take into account the insects that have not laid eggs, and this case will be exceptionally rare.

In neither of these cases can the sirividhi traverse long distances, and the spreading of the evil is therefore slowly effected. Thence we may see two fields near each other or separated by deep trenches or ravines one attacked by sirividhi and the other remaining immune for years. It has been also observed that a part of a field, which has happened to catch fire or which has served as a place for burning charcoal has in the following year been free from sirividhi, whereas the other part of the field has been alive with these insects. Again sirividhi has appeared in one-half of a field sown with wheat whilst the other half for reasons to be given hereafter remained free during the growth of the wheat, the sirividhi worms having limited themselves to those spots where they first appeared.

We may therefore conclude from the foregoing that the spreading of the pest is slow, and that the sirividhi locates itself in certain fields.

The sirividhi is, however, conveyed long distances by man unconsciously either in the form of egg or worm or even chrysalis. There are many villages in the Island, whose inhabitants possess cornfields in other distant villages in the plains. To many of those villages the sirividhi has been conveyed by means of the plough. Thus the inhabitants of Sylikou, a village situated on the N. W. of Lania, who own cornfields in Pissouri, have conveyed the sirividhi from that place to the lands near to their village, which of course they till with the same ploughs. By the same means the sirividhi is spread from the lower lands of the same village to the fields situated higher up, as has been the case in Pissouri, Phassoulla and elsewhere.

Again the pest is conveyed by worm infested green fodder or by chrysalides transported in the same way. This explains the appearance of the sirividhi in isolated places very far from the original home of the insect, whilst the lands of the villages between are quite uninjured.

Natural Enemies.—The œcophora of wheat does not always appear here with the same intensity. In some years the damage caused by it is so little that its appearance in cornfields remains unnoticed. Sometimes it may disappear altogether for reasons we shall mention later on. Natural causes such as atmospherical conditions, and the multiplication of parasites, which interfere with the development and propagation of this enemy of cereals, tend to keep this evil in check.

Early in the year showers destroy numbers of grubs while in the ground, whereas the retention of moisture in the soil might also kill both eggs and caterpillars. Therefore in naturally damp soils or where corn crops are irrigated this insect is not much seen or it may make its appearance only on the edges of fields, as they are more aired and therefore, retain less moisture. For the same reason, fertile and thickly sown lands suffer but little from the sirividhi worm.

This circumstance so unfavourable to the hatching of the sirividhi eggs, seems to exercise no influence once the insect has had time to penetrate the leaves of crops. Bitter cold also has no injurious effects upon the worms of the insect. This at any rate was noticed last year, when we have had the most bitter cold at the time of the early development of the sirividhi. The showers that fall after the appearance of the moths may perhaps kill many of them, but such rainfalls are rare here in that season, and the benefit resulting therefrom is little or nothing when the insects so destroyed have already laid their eggs.

But in addition to unfavourable atmospheric influences the sirividhi has also a natural foe, which destroys it when in the chrysalis stage. This enemy is another insect, an ichneumon—Anilastus tricinctus.—The insect is 6½ m.m. long. Its head, eyes, feelers and thorax are black, the wings irisated, the abdomen and the legs orange-yellow. This insect abounds in the cornfields that are infested with sirividhi. The appearance of this ichneumon occurs shortly after the metamorphosis of the caterpillar of sirividhi into a chrysalis, and the females of the ichneumon lay their eggs inside the cocoons of the sirividhi in order to secure the necessary food for their young. *

Fig. 19. Anilastus Tricinctus, magnified. (Original.)

Each ichneumon needs from 40 to 50 chrysalides in order to secure its succeeding generation. There are years when most of the chrysalides of the sirividhi are attacked by this insect, friend and ally of the farmer, and the sirividhi is consequently rare during those years, the ichneumons on the other hand being very numerous. The latter, in their turn, not having the means any longer to insure the laying of their eggs, perish in great numbers without offspring, and then the sirividhi being exposed no further to the attacks of this terrible foe, commence multiplying again. Thus it is by the struggle for existence that in many cases certain insects appear and disappear successively.

As, however, we have not always the help of these natural allies, or rather, as we must not depend upon their assistance, but must rely on our own exertions, we should carry on a vigorous attack against these enemies of our crops, by applying the following treatment, the efficacy of which we are able to appreciate from the knowledge we have now gained of the life circle of the sirividhi.

Means for combating the Sirividhi.—The combating of the œcophora can be carried out easily by the methods mentioned hereinafter, which, if applied persistently and carefully by all the landowners in the areas infested with sirividhi, can within a few years bring about the entire extermination of this pest of cereals.

But the lifetime of the insect being completed during the growth of crops, the combating of the sirividhi should be carried on against the grubs, and their destruction can be effected both on fallow lands, where grubs are found living on various wild plants, and on lands sown with cereals in their early stage of development and after reaping.

In the former case the eradication of this injurious insect is attained through careful and repeated ploughing by means of which the development of weeds on many of which the sirividhi feeds is hindered. As I

* The chrysalides of the ichneumon are chestnut-brown, and this colour is visible through the walls of the cocoon and serves as a characteristic feature of the cocoons, which contain healthy chrysalides of the sirividhi, the skin of which is, as we have said, like honey in colour,

have myself ascertained, the worm of the œcophora feeds on the leaves of the sinapis nigra (charlock) and plantago major and minor, on the leaves of a wild tropaeolum, of dog-grass and on the flowers of the wild convolvulus (convolvulus arvensis) all of which grow abundantly in the cultivated lands here.

The existence and development of the aforesaid weeds is due to the native plough, which has the disadvantage of not turning over and pulverizing the earth, but leaving behind it large clods, most of which not being turned over altogether or at all, keep their vegetation on which the sirividhi continues to live and complete its development. Therefore the destruction of the host plants on which the worm feeds would bring about at the same time the extermination of the worm through starvation. And this may be effected to some extent by the native plough, when ploughing is made carefully and at the proper time—when the earth is, as people say here in its "ὄργον"—in proper tilth—and cross-ploughing follows in a few days afterwards, and a third ploughing in February. But the eradication of the host plants is effected more easily by the European plough, the introduction of which is imperative on the cornfields infested with the sirividhi. The beneficial action of the European plough has been demonstrated by me in the experimental field at Pissouri, in which the special plot was cultivated with the European plough and grew wheat nearly free from sirividhi.

The good results of cultivation carefully carried out against sirividhi are admitted even by farmers themselves as they notice that the sirividhi appears more rarely and in fewer numbers in those fields, which had grown summer crops such as cotton, vetches, sesame, etc., and which therefore were repeatedly tilled from the month of January. Such examples of fields are numerous in the area of Pissouri and in other places, where the cultivation of summer crops is followed by that of cereals. The sirividhi has entirely disappeared from the lands of the village of Lania through the introduction of the cultivation of vetches.

Moreover, it is necessary to destroy all the weeds growing on the banks round the field and along the sides of lanes and paths on which the sirividhi feeds and consequently secures the perpetuation of its own species.

The freeing of a field from the grubs of the œcophora after their appearance can be effected by driving sheep or goats into such field in January to graze the standing crops. The grazed crop will then send up new shoots, which are free from sirividhi. We have applied this method in one of the pieces of the experimental field in Pissouri with wonderful success.

A third means for combating the sirividhi is to burn the stalks left after reaping. By burning the stems the grubs of the œcophora will be destroyed as well. To do this successfully the reaping should be done a little higher than usual from the ground, that is, the greater part of the stalk should be left standing, and the fire started when there is wind. We suggest this method, knowing by experience that the portion of a field infested with sirividhi, the stalks of which were burned, grew in the following year crop which bore no sirividhi. By this means large tracts of land in Poli-tis-Chrysokhou have been freed from that pest of cereals.

These are the methods we propose and, although simple, yet they conduce to the destruction of the worm of the œcophora, as we have been satisfied by the facts. It is now quite certain that everything depends on the farmer. When there are or appear such insects in a field, the farmer must wage systematic war with them, by using the above mentioned means according to the season, doing his best to apply them carefully for the extermination of this terrible foe of his harvest, bearing always in mind that even in agriculture " it is better to go ahead than remain behind".

D. Saracomenos,

Director of Agriculture.